(12) UK Patent Application (19) GB (11) 2 218 778 (13) A

(43) Date of A publication 22.11.1989

(21) Application No 8911416.9

(22) Date of filing 18.05.1989

(30) Priority data
(31) 63065846 (32) 20.05.1988 (33) JP

(71) Applicant
Tochigifujisangyo Kabushiki Kaisha

(Incorporated in Japan)

2388 Ohmiya-machi, Tochigi-shi, Tochigi-ken, Japan

(72) Inventor
Hiroshi Ishikawa

(74) Agent and/or Address for Service
Marks & Clerk
57-60 Lincoln's Inn Fields, London, WC2A 3LS,
United Kingdom

(51) INT CL[4]
F16D 3/80

(52) UK CL (Edition J)
F2U U504 U508 U536 U541
B7H HDG H512 H571
U1S S1820

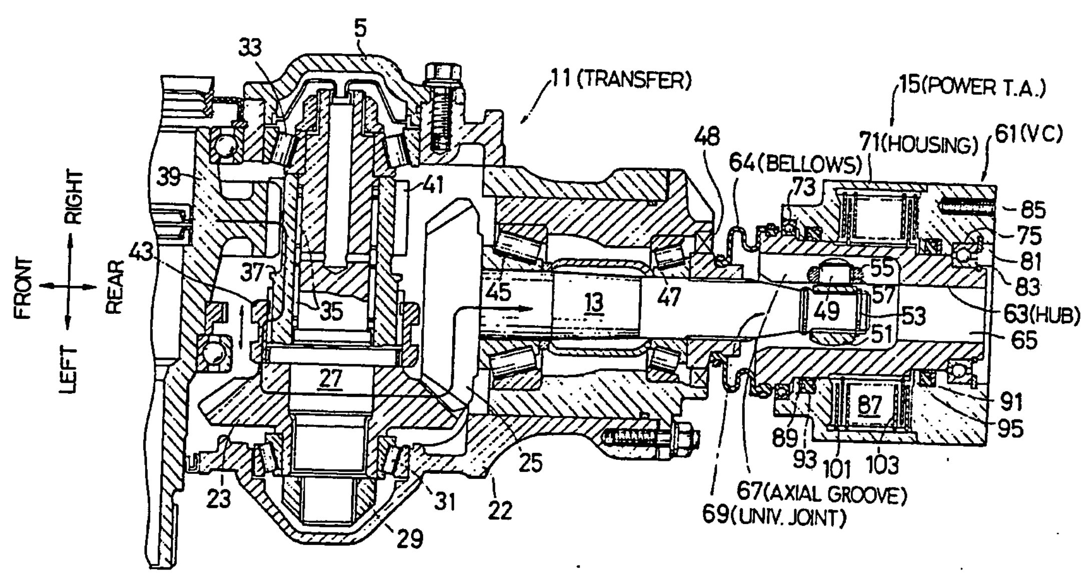
(56) Documents cited
None

(58) Field of search
UK CL (Edition J) F2U
INT CL[4] F16D 3/00

(54) Power transmission apparatus

(57) To reduce the arrangement space of a viscous coupling device and a universal joint, the power transmission apparatus comprises a constant velocity universal joint 69 attached to an end of an input shaft 13; a hub 63 with axially extending inner grooves 67 axially slidably engageable with the universal joint 69; a housing 71 rotatably fitted to the hub 63 and adapted to be coupled to an output shaft; and a viscous coupling device 61 disposed between the hub 63 and the housing 71. Therefore, power can be transmitted from the input shaft to the output shaft, or vice versa, in inclination conditions. Further, since the universal joint is covered by the viscous coupling device, it is possible to protect the universal joint from rain or mud, thus improving durability. The universal joint may be a tripod joint (Figs. 4A and B) or a double offset joint (Figs. 5A and B).

FIG. 3



GB 2 218 778 A

FIG. 1A

PRIOR ART

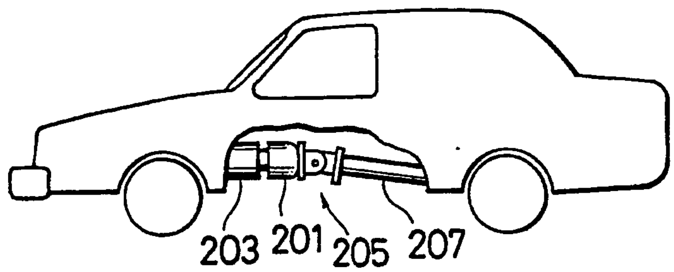


FIG. 1B

PRIOR ART

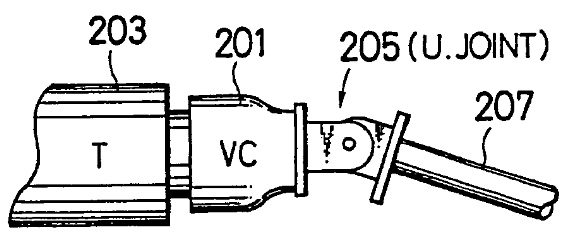


FIG. 1C

PRIOR ART

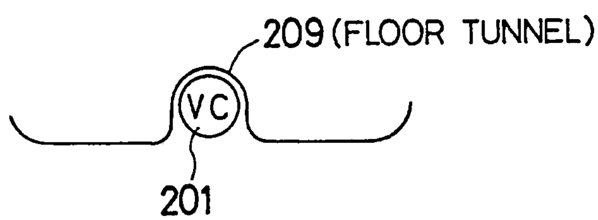


FIG. 2A

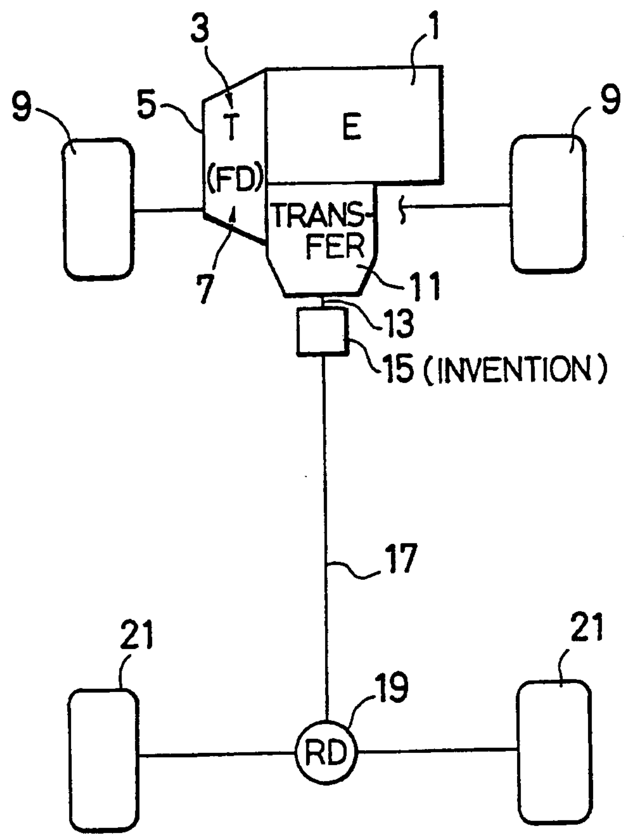
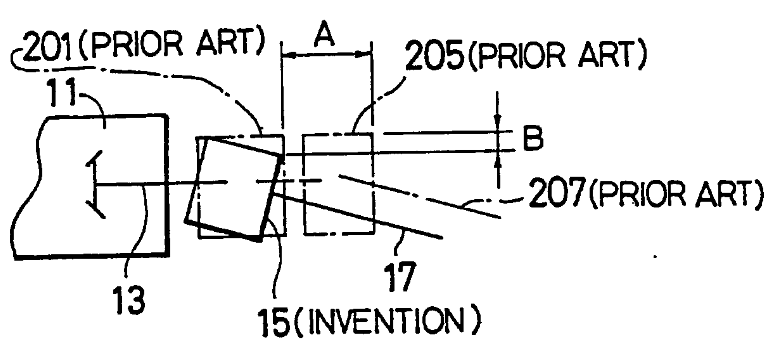

3
1
9
5
T
E
9
(FD)
TRANS-
FER
7
11
13
15 (INVENTION)
17
21
21
19
RD

FIG. 2B


201 (PRIOR ART)
A
205 (PRIOR ART)
11
B
207 (PRIOR ART)
13
17
15 (INVENTION)

3/5

2218778

F I G. 3

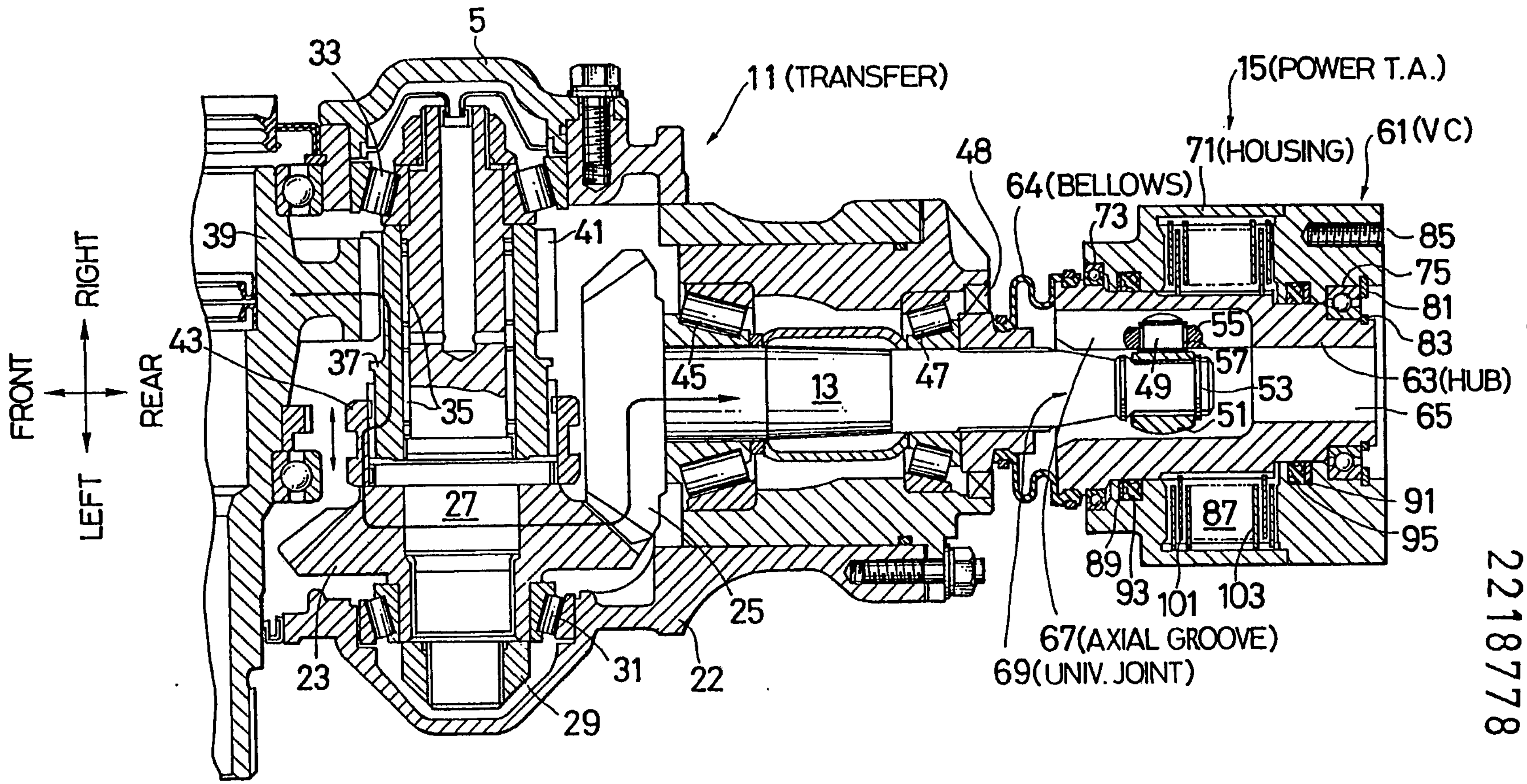


FIG.4A

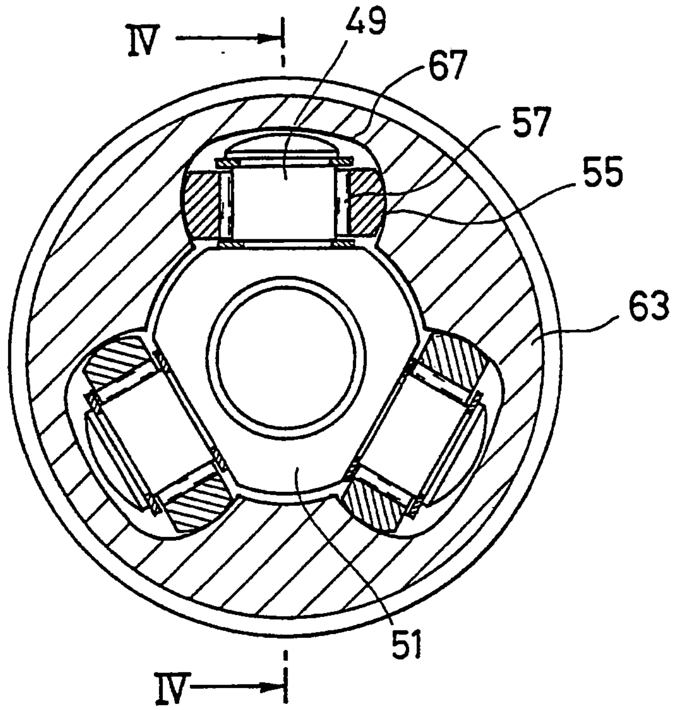

IV
49
67
57
55
63
51
IV

FIG.4B

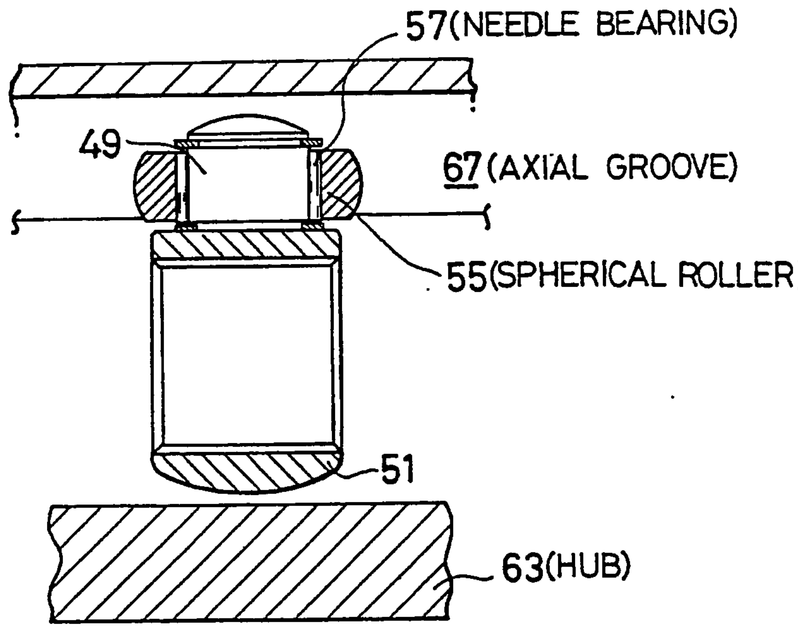

57(NEEDLE BEARING)
49
67(AXIAL GROOVE)
55(SPHERICAL ROLLER)
51
63(HUB)

FIG.5A

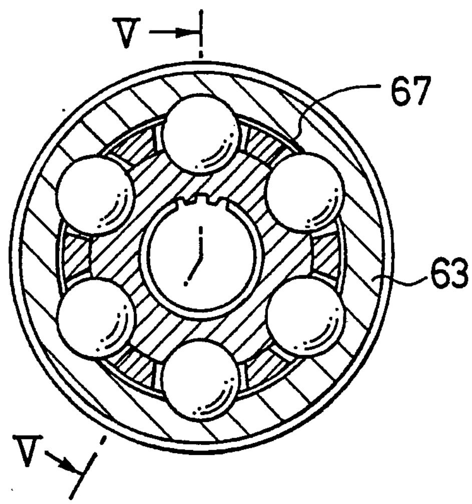
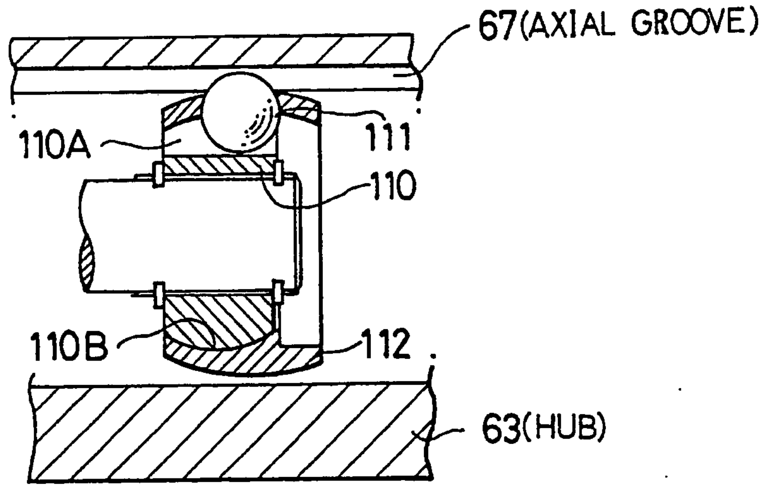


FIG.5B



POWER TRANSMISSION APPARATUS

The present invention relates to power transmission apparatus, for a four-wheel drive vehicle, for instance, and more specifically to apparatus for transmitting power from an input shaft to an output shaft coupled to the output shaft at an inclination angle.

In an FF (front engine, front drive)-based full-time 4WD (four wheel drive) vehicle, for instance, it is necessary to transmit engine drive power from the front wheel side to the rear wheel side via a viscous coupling device. An example of the above-mentioned power transmission apparatus is disclosed in Japanese Published Unexamined (Kokai) Utility Model Application No. 59-1887, as shown in Figs. 1A and 1B. In the drawings, a hub of a viscous coupling device 201 is connected to a drive pinion of a transfer 203, and a housing of the viscous coupling device 201 is connected to a propeller shaft 207 via a universal joint 205.

In the prior-art power transmission apparatus as described above, since the viscous coupling 201 and the transfer 203 are connected to each other in a straight line via a drive pinion and further the viscous coupling 201 is connected to the propeller shaft 207 via the universal joint 205, there exist various problems in that a large space is needed to dispose the viscous coupling 201 and the universal joint 205 and further the durability of the universal joint 205 is not sufficient because the joint is exposed. In this connection, since a large space is

required, the diameter of the vehicle floor tunnel 209 is large and therefore the accommodation space within the passenger compartment is decreased; the wheel base (horizontal distance between the front and rear wheel shafts) is increased. Further, the above-mentioned drawbacks inevitably reduce the degree of freedom in layout of various vehicle components and in design of wheel base.

With these problems in mind, therefore, it is the primary object of the present invention to provide a small-sized and durable power transmission apparatus for transmitting power via a viscous coupling device and a universal joint.

To achieve the above-mentioned object, the power transmission apparatus for transmitting power from an input shaft to an output shaft coupled to the input shaft at an inclination angle or vice versa, according to the present invention, comprises: (a) an equal velocity universal joint (69) attached to an end of the input shaft (13); (b) a hub (63) formed with axially extending inner grooves (67) axially slidably engageable with the equal velocity universal joint; (c) a housing (71) rotatably fitted to an outer circumference of said hub and coupled to the output shaft (17); and (d) a viscous coupling device (61) disposed between said hub and said housing. The equal velocity universal joint is a tripode joint, double offset joint, etc.

In the power transmission apparatus according to the present invention, since the viscous coupling device and the universal joint are combined, it is possible to reduce the arrangement space markedly and therefore to increase the degree of arrangement layout freedom and decrease the height of the floor tunnel within the passenger

compartment. Further, since the input and output shafts are coupled via an equal velocity universal joint, it is possible to transmit power from the input shaft to the output shaft or vice versa under inclination conditions. Further, since the viscous coupling device is provided between the hub and the housing, it is possible to absorb a difference in rotational speed between the two shafts. Further, since the universal joint is covered by the viscous coupling device, it is possible to protect the universal joint from rain water and muddy water and therefore improve the durability thereof.

The features and advantages of the power transmission apparatus according to the present invention will be more clearly appreciated from the following description of the preferred embodiments of the invention taken in conjunction with the accompanying drawings in which:

Fig. 1(A) is a partly broken side view for assistance in explaining an example of prior-art power transmission apparatus provided for an automotive vehicle;

Fig. 1(B) is an enlarged side view showing the prior-art power transmission apparatus shown in Fig. 1(A);

Fig. 1(C) is an illustration for assistance in explaining the height of a floor tunnel under which a prior-art viscous coupling device is arranged;

Fig. 2A is a diagrammatical view for assistance in explaining a power transmission apparatus according to the present invention applied to a power transmission system for an FF-based full-time 4WD vehicle;

Fig. 2B is an illustration for assistance in explaining advantages of the power transmission apparatus according to the present invention in comparison with the prior-art power transmission apparatus;

Fig. 3 is an enlarged cross-sectional view showing a transfer of a 4WD vehicle and an embodiment of the power transmission apparatus according to the present invention;

Fig. 4A is an enlarged side view showing a tripod joint slidably fitted to an axial groove of a hub;

Fig. 4B is a cross-sectional view taken along the line IV-IV in Fig. 4A;

Fig. 5A is an enlarged side view showing a double offset joint fitted to an axial groove of a hub; and

Fig. 5B is a cross-sectional view taken along the line V-V in Fig. 5A.

An embodiment of the power transmission apparatus according to the present invention will be described with reference to the attached drawings. Fig. 2A shows an example where the power transmission apparatus 15 of the present invention is applied to an FF (front engine front drive)-based full-time 4WD (four wheel drive) vehicle.

In Fig. 2A, rotational drive power of an engine 1 arranged in the vehicle lateral direction is gear changed via a transmission 3, differentially distributed to the right and left front wheels 9 via a front differential gear 7 housed in a transmission case 5, transmitted to a rear differential gear 19 via a transfer 11, a drive pinion shaft 13, and the power transmission apparatus 15 according to the present invention, and further differentially distributed to the right and left rear wheels 21 via a rear differential gear 19.

With reference to Fig. 2B, in the case of prior-art power transmission apparatus, the transfer 11, the viscous coupling device 201, and the universal joint 205 are arranged in a straight line, and the propeller shaft 207 is connected to the universal joint as shown by dot-dashed lines in Fig. 2B. In contrast with this, in the case of

the power transmission apparatus according to the present invention, the viscous coupling and the universal joint are incorporated in combination and directly connected to a propeller shaft 17, as shown by solid lines in Fig. 2B. Therefore, it is possible to reduce the wheel base dimension by a distance A and the floor tunnel dimension by a height B in Fig. 2B, as compared with the prior-art power transmission apparatus. Further, since the universal joint is housed within the apparatus, it is possible to protect the universal joint from rain water and muddy water.

The apparatus of the present invention will be described in more detail herein below with reference to Fig. 3, which shows a prior-art transfer 11 on the left side and an embodiment of the apparatus according to the present invention on the right side.

A change-direction gear assembly composed of first and second bevel gears 23 and 25 in mesh with each other is housed within a transfer case 22 of a transfer 11. The first bevel gear 23 is spline coupled to an intermediate shaft 27 arranged in the vehicle width (right and left) direction on the left side of the vehicle, and fixed to the intermediate shaft 27 with a lock nut 29. The intermediate shaft 27 is rotatably supported by the transfer case 22 with a first bearing 31 (indirectly via the first bevel gear 23) on the left side and with a second bearing 33 on the right side.

A sleeve 37 is rotatably fitted to the intermediate shaft 27 via a needle bearing 35. A gear 41 is formed integral with the sleeve 37 on the right side and in mesh with another gear 39 to transmit a drive power of the engine 1. A coupling sleeve 43 is axially slidably spline engaged with both the sleeve 37 and the intermediate shaft 27 on the left side. Therefore, when the coupling sleeve 43 is moved in the axial direction, the coupling sleeve 43 is engaged with or disengaged from the spline formed on the

large diameter portion of the intermediate shaft 27. The coupling sleeve 43 is moved along the sleeve 37 when a lever (not shown) is operated by a driver, so that the sleeve 37 is coupled to or decoupled from the intermediate shaft 27 via the coupling sleeve.

As described above, a 2-4WD switching mechanism for switching 2WD to 4WD or vice versa can be constructed by connecting and disconnecting engine drive power to and from the rear wheel 21. That is, only when the intermediate shaft 27 and the sleeve 37 are coupled by the coupling sleeve 43 or by the 2-4WD switching mechanism, engine drive power is transmitted from the gear 39 to the change-direction gear assembly 23, 25 by way of the sleeve 37, the coupling sleeve 43, and the intermediate shaft 27.

The second bevel gear 25 is formed integral with a drive pinion shaft 13 on the front side. The drive pinion shaft 13 is arranged perpendicular to the intermediate shaft 27, geared with the shaft 27 via the change-direction gear assembly composed of the first and second bevel gears 23 and 25, and rotatably supported by the transfer case 22 via two bearings 45 and 47. Further, a seal 48 is watertightly fitted to the rear side of the bearing 47 disposed on the rear side of the transfer case 22.

The power transmission apparatus 15 according to the present invention will be described with reference to Fig. 3 (on the right side). The apparatus of the present invention comprises a viscous coupling device 61 provided between a hub 63 and a housing 71, and an equal velocity universal joint 69.

The equal velocity universal joint 69 is attached to the rearmost end of the drive pinion shaft 13 and fixed thereto by a retainer 53.

The hub 63 of the viscous coupling 61 is formed with a central hollow portion 65. This hollow portion 65 is further formed with three axially extending grooves 67 at

regular angular intervals so as to be engaged with the equal velocity universal joint 69 in such a way that the viscous coupling device 61 can be rotated together with the drive pinion shaft 13 and further slidably inclined with respect to the drive pinion shaft 13. The equal velocity universal joint is a tripod joint, a double offset joint, etc.

Figs. 4A and 4B show a tripod joint as an example of the equal velocity universal joint 69 incorporated in the apparatus according to the present invention. The tripod joint comprises an annular member 51 spline coupled to the end of the drive pinion shaft 13, three arms 49 extending radially from the annular member 51 at regular angular intervals, and three spherical rollers 55 rotatably supported by the three arms 49, respectively via needle bearings 57 each fitted to each arm 49. Each spherical roller 55 is formed with an outer circumferential spherical surface so as to be slidably and rotatably engageable with two side spherical surfaces of each axially extending inner groove 67 formed in the hub 63. Therefore, when the tripod joint is rotated, the hub 63 can be rotated together with the tripod joint. Further, when the hub 63 is inclined with respect to the drive pinion shaft 13, the spherical rollers 55 can smoothly be rotated via the needle bearings 57 within the axial grooves 67 and further slide on and along the inner spherical surfaces of the axial grooves 67 of the hub 63.

Figs. 5A and 5B show a double offset joint as an example of the equal velocity universal joint 69 incorporated in the apparatus according to the present invention. The double offset joint comprises a plurality of balls 111 slidably and rotatably engageable with the axially extending inner grooves 67 of the hub 63, an inner casing 110 fitted to the end of the drive pinion shaft 13 and formed with a first spherical surface 110A for

receiving a plurality of balls 111 and with a second spherical surfaces 110B, and an outer casing 112 formed with plural holes for holding the balls and with inner spherical surfaces slidably engageable with the second spherical surface 110B of the inner casing 110. Since the balls 111 are engaged with the axial semicircular grooves 67 formed in the hub 63, when the double offset joint is rotated, the hub 63 can be rotated together with the double offset joint via the balls 111. Further, when the hub 63 is inclined with respect to the drive pinion shaft 13, the inner casing 110 fixed to the drive pinion shaft 13 can be smoothly and slidably pivoted relative to the outer casing 112 via the engaged spherical surfaces 110B, and further the balls 111 can be slid on and along the inner semispherical surfaces of the axial grooves 67 of the hub 63.

A bellows 64 is disposed between the hub 63 and the drive pinion shaft 13 on the front side of the hub 63, and a cover (not shown) is fitted to the hub 63 on the rear side of the hub 63 to close the hollow portion 65 thereof.

The housing 71 is rotatably supported by the hub 63 via bearings 73 and 75. The bearing 75 is located between the hub 63 and the housing 71 with two circle clips 81 and 83. Further, bolt holes 85 are formed on the rear surface of the housing 71 to fix flange portions (not shown) of the propeller shaft 17 (shown in Fig. 2A) with bolts.

An annular working chamber 87 is formed between the hub 63 and the housing 71. Two X rings 93 and 95 are fitted to fitting grooves formed on the front and rear sides of this working chamber 87 with each backup ring 89 or 91 located outside in order to enclose the working chamber 87. This working chamber 87 is filled with a high viscous silicone oil. Within the working chamber 87, a plurality of inner resistance plates 101 are radially engaged with the hub 63, and a plurality of outer

resistance plates 103 are radially engaged with the housing 71 so as to be alternately disposed relative to the inner resistance plates 101.

The function of the power transmission apparatus 15 thus constructed will be described hereinbelow.

When the 2-4WD switching mechanism is switched from 2WD to 4WD, rotational drive power of the engine 1 rotates the drive pinion shaft 13 of the transfer 11, so that the hub 63 of the viscous coupling device 61 is rotated via the equal velocity universal joint 69. Under these conditions, although the central axis of the propeller shaft 17 is inclined with respect to that of the drive pinion shaft 13 and therefore the viscous coupling device 61 is inclined with respect to the drive pinion shaft 13, since the equal velocity universal joint 69 attached to the drive pinion shaft 13 slides within the axial grooves 67 of the hub 63 in the axial direction thereof, the drive pinion shaft 13 and the hub 63 can rotate at the same angular velocity. Further, when the universal joint 69 slides along the axial grooves 67, since the spherical rollers 55 or balls 111 within the axial grooves 67, the frictional resistance can be reduced.

The rotation of the hub 63 is transmitted from the inner resistance plates 101 to the outer resistance plates 103 owing to the shearing resistance of the silicon oil within the working chamber 87, so that the housing 71 is rotated to transmit power to the rear wheels 21 via the propeller shaft 17 (both shown in Fig. 2A).

The function and the effect of the present invention will be explained in relation to a vehicle.

When the vehicle is travelling on a paved road, the rear wheels are rotated together with the front wheels owing to the presence of the viscous coupling device 61.

Therefore, even in 4WD conditions, the vehicle is substantially driven by FF-based 2WD travelling conditions.

Further, when the front wheels 9 slip and therefore a big difference in rotational speed is produced between the front and rear wheels 9 land 21, since a torque can be transmitted immediately to the rear wheels 21, the vehicle can travel smoothly. Further, when the vehicle is sharply turned at low speed as when the vehicle is put into a garage, since the twist of the propeller shaft 17 can be absorbed by the viscous coupling device 61, it is possible to prevent the occurrence of tight corner braking phenomenon. In addition when the vehicle is travelling on a muddy road, since an appropriate torque can be transmitted to the front and rear wheels 9 and 21 according to change in road surface resistance, it is possible to drive the vehicle under excellent drive performance.

As already explained with reference to Fig. 2B, since the power transmission apparatus 15 according to the present invention including both the viscous coupling device and the universal joint together can be oscillated as shown by solid lines in Fig. 2B, it is possible to reduce the wheel base dimension by a distance A and the floor tunnel dimension by a height B, in comparison with the prior-art arrangement in which the viscous coupling device 201 and the universal joint 205 are disposed separately as shown by dot-dashed lines in Fig. 2B. Therefore, it is possible to increase the accommodation space of the passenger compartment by reducing the height of the floor tunnel 209 (shown in Fig. 1C). Further, since no additional universal joint 205 is used, the weight thereof can be reduced, while shortening the propeller shaft 17 or the wheel base by the dimension A. Further, since the engage portion of the equal velocity universal joint 69 is disposed within the hub 63 of the viscous coupling device 61, it is possible to protect the equal velocity universal joint 69 from rain water or muddy

water, and further it is possible to enclose lubricant within the hollow portion 65 of the hub 63 for sufficient lubrication.

As described above, in the power transmission apparatus according to the present invention, since the central axes of the input and output shafts are coupled at an inclination angle with respect to each other, it is possible to increase the degree of layout freedom near the transfer, decrease the arrangement space and the apparatus weight. Further, since the universal joint can be covered by the viscous coupling device, it is possible to increase the durability thereof.

Claims:-

1. Power transmission apparatus for transmitting power from a first shaft to a second shaft coupled to the input shaft at an inclination angle, or vice versa, which comprises:

(a) an equal velocity universal joint adapted to be attached to one end of the first shaft;

(b) a hub formed with axially extending inner grooves axially slidably engageable with the universal joint;

(c) a housing rotatably fitted to an outer circumference of the hub and adapted to be coupled to the second shaft; and

(d) a viscous coupling device disposed between the hub and the housing.

2. Power transmission apparatus as claimed in claim 1, wherein the viscous coupling device comprises:

a plurality of inner resistance plates radially engaged with an outer circumferential surface of the hub;

a plurality of outer resistance plates radially engaged with an inner circumferential surface of the housing; and

a working chamber formed between the hub and the housing and filled with a viscous fluid.

3. Power transmission apparatus as claimed in claim 1 or 2, including a bellows for connecting the hub to the first shaft.

4. Power transmission apparatus as claimed in any of claims 1 to 3, wherein the universal joint is a tripod joint comprising:

an annular member adapted to be fitted to the end of the first shaft and formed with three arms extending radially from the annular member at regular angular intervals; and

three rollers rotatably supported by the respective arms, each roller being formed with an outer circumferential spherical surface so as to be slidably and rotatably engageable with two spherical lateral surfaces of a respective one of the axially extending inner grooves of the hub.

5. Power transmission apparatus as claimed in any of claims 1 to 3, wherein the universal joint is a double offset joint comprising:

a plurality of balls slidably and rotatably engageable with the respective axially extending inner grooves of the hub;

an inner casing adapted to be fitted to the end of the first shaft and formed with first spherical surfaces for supporting the balls and second spherical surfaces; and

an outer casing formed with holes for holding the balls and with inner spherical surfaces slidably engageable with the second spherical surfaces of the inner casing.

6. Power transmission apparatus substantially as described with reference to, and as shown in, Figure 3 and either Figures 4A and B or Figures 5A and B of the accompanying drawings.

Published 1989 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent, Con. 1/87